PA illustrations by BOB SAULS/JF& POPULAR SCIENCE SEPTEMBER 2002 TYPICAL SCENE FROM THE troops and vehicles, more powerful communications satelconflict in Afghanistan, lites to give soldiers cellphone-like connections, and orbiting where for the first time sensors that can track ballistic missiles. The hardware on the space-specifically, more Pentagon's wish list includes items that have offensive as than one hundred orbitwell as defensive potential-such as a military spaceplane, a ing military satellitesspace-based laser, and a reentry vehicle that could drop has been a centerpiece of bombs of virtually any size. Here's a preview of what may the war machine: A solbe in orbit in the coming years. dier on the ground spots SPY SATELLITES a Taliban target. With a THE NATIONAL RECONNAISSANCE OFFICE AND THE PENTAGON lightweight, handheld Global Positioning Sysare planning to replace virtually their entire inventory of

to an air base in Florida. From there, an alert is sent to commanders in Saudi Arabia, who direct a Predator drone to fly over the Taliban site and relay real-time video of the sceneagain, via satellite. The target is approved for bombing, and a B-52 pilot, cruising more than 20,000 feet overhead, safely out of range of antiaircraft missiles, punches the GPS coordinates into the computer of a Joint Direct Attack Munitions (JDAM) bomb before releasing it. The bomb uses its own GPS receiver to careen Earthward toward the target, exploding within a few feet of it. The whole process takes only minutes, not days as in previous wars. And the \$20,000 JDAM bomb is a bargain compared with already old-fashioned \$100,000 laser-guided bombs, which have difficulty finding their targets through dust, clouds, and smoke. But there were regrettable incidents as well. In December, after an Air Force spotter calculated the position of a Taliban target with his plugger, the device's battery went dead. The spotter changed the battery and relayed the GPS coordinates

to a B-52 approaching the target. What the spotter didn't realize was that his plugger was programmed to display the

coordinates of its own location upon rebooting. A 2,000-

pound JDAM bomb landed with devastating precision,

killing three Special Forces soldiers and five Afghan allies.

be unreliable. GPS signals are easily jammed; the sharpest-

eyed spy satellites have trouble seeing through clouds; and communications among myriad military forces and systems

frequently clog the airwaves. Meanwhile, military satellites are completely undefended and vulnerable to attack.

future warfare, say Secretary of Defense Donald Rumsfeld and others within the administration, is "space control."

Defense strategists aren't just concerned about repairing

The solution, if space is going to play a bigger role in

Even without human error, space military technology can

tem (GPS) receiver known as a "plugger," he uses the con-

stellation of GPS satellites to calculate the longitude and lat-

itude of his mark and phones in the coordinates, via satellite,

deficiencies; they see space as a new and largely unexploited frontier. In other words, they want to seize the high ground in space-not just to watch the globe for enemy activities or to launch strikes from space, but also to deny adversaries access to space as a military vantage point. It's a risky approach, with its share of critics, because it invites countermeasures from potential adversaries and terrorists and possibly all-out war in space. Still, riding this doctrine, U.S. military planners are pursuing dozens of space-based technology efforts. New assets in the works include satellites that can see through camouflage, space-based radar that can monitor the movements of

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instance, in uncovering a tank hidden by a camouflage net, because infrared imaging would detect the heat coming from the engine (see "Nowhere to Hide," Aug. '01). Another technology under review is a space-based radar network that will continuously bounce signals off Earth's surface and under all conditions—even low clouds, storms, or darkness—detect moving targets such as trucks and missile launchers. "If you're a bad guy and you move, we'll see you move," says Robert Dickman, deputy for military space in the Office of the Undersecretary of the Air Force. The military already uses airplane-mounted radar to spot moving ground targets—such as during surveillance of the

"Highway of Death," the main road between Kuwait and Iraq during the Persian Gulf War. And in 1994 and 2000, NASA

successfully orbited radar systems on the space shuttle. But

for the global, around-the-clock radar coverage that the Pen-

tagon wants—a system that would not risk pilots' lives or

intrude in foreign airspace—a constellation of two dozen or

more high-powered satellites in low Earth orbit would be

needed. "We would like to be able to fly around the end of the decade," says Dickman, "but space-based radar is a tough chal-

imaging satellites during the next decade or so at a cost of

more than \$60 billion. The plan is to buy a fleet of birds with

much keener eyes than today's optical imaging satellites and eventually to purchase equipment that can, unlike current

One technology under consideration: hyperspectral satel-

lites that take images in hundreds of different infrared and

visible bands of light. Such satellites could be useful, for

satellites, provide continuous visual data about a target.

lenge technologically and it's also a challenge financially." The key obstacles: Not only must the system provide a penetrating view of "denied" territory from a great distance, well above where an airplane can fly, but it must also be integrated with existing communications equipment so that information can be instantly relayed to forces on the ground and in the air. And even if these problems are overcome, using existing satellite technology it may not be possible to place enough of these devices in space to achieve full coverage because of the billions of dollars it takes to build and launch them. Congress has already killed one proposed satellite radar network, known as Discoverer II, because it didn't

meet cost expectations, and the Air Force and MIT's Lincoln

Laboratory are currently conducting an analysis of alterna-

One possibility is the Technology Satellite of the 21st Cen-

tury, or TechSat 21, a concept being studied by the Air Force

Research Laboratory (see "One System, Many Eyes," page 44). Instead of large satellites the size and weight of cars,

tives expected to be completed in November of next year.

MAKING AMERICA SAFE | SPACE because by simply reconfiguring clusters, operators will be able to conduct different missions. For example, the same group of microsatellites could be initially widely spaced to provide worldwide radar coverage, and then within hours moved closer together to conduct finetoothed searches of smaller areas. Much work remains to be done before TechSat 21 will be ready. For example, researchers must figure out how to keep the microsatellites in their tight pattern of slightly different orbits without burning too much fuel. The first real demonstration of the TechSat 21 concept will occur in 2005, when the Air Force plans to launch a cluster of three identical microsatellites to see whether they can fly in a precise formation.



military applications, are used for everything from crop surveys to creating digital maps in cars—is that they will have separate signals for military and civilian use. This will make

THE MARKED DIFFERENCE BETWEEN THE NEXT generation of location-finding GPS satellites, known as GPS III (see "Jam-Proof Signals" at left), and current models-which, besides

it more difficult for enemies to jam military output. The importance of this capability was underscored two years ago when engineers from the Air Force Research Laboratory used

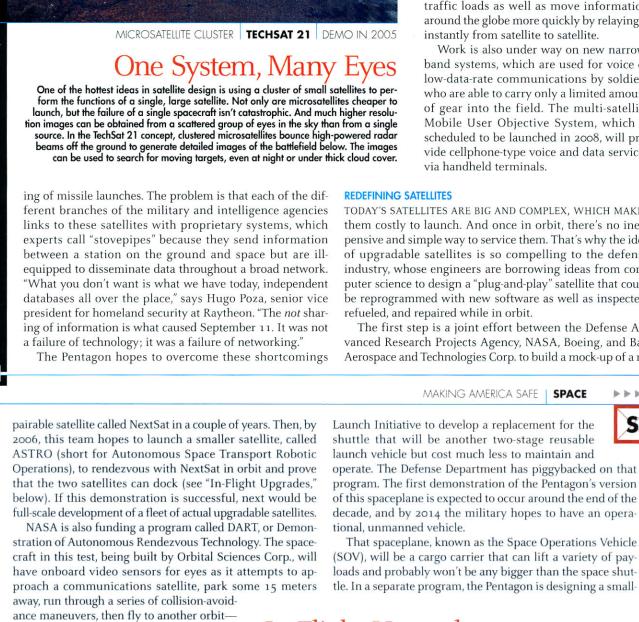
instructions downloaded from the Internet to build a \$7,500 homemade device that easily drowned out GPS signals in a flood of electronic noise. That demonstration stoked the fear that any enemy with little more than access to the Web could sidetrack a smartbomb attack. To avoid this, GPS III, scheduled to be ready by the end of the decade, will transmit a higher-powered and more concentrated signal than what is provided by existing equipment. These so-called spot beams will be virtually impossible to jam without expensive and sophisticated devices. GPS III satellites will also have improved clocks. The more precise the temporal information sent from the satellites to receivers on the ground, the better the receivers can

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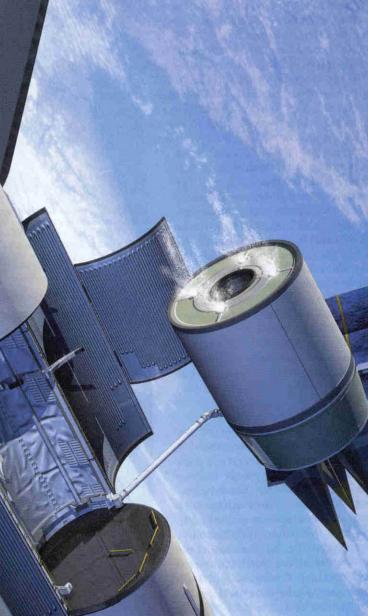
One of the significant deficiencies to be

In a further effort to increase bandwidth,

newest far-flung and undeveloped regions of conflict. Detailed pictures from unmanned Predator and Global Hawk airplanes can easily overload military networks, especially in places like Afghanistan where there is very little existing telecom infrastructure. In 2004, the military plans to debut the first of its Wideband Gapfiller Satellites, which will have "active" antennas with multiple communications beams that can be focused anywhere that extra bandwidth is needed. Each of these satellites will be able to provide more bandwidth than 10 of today's wideband



puter science to design a "plug-and-play" satellite that could be reprogrammed with new software as well as inspected, refueled, and repaired while in orbit. The first step is a joint effort between the Defense Advanced Research Projects Agency, NASA, Boeing, and Ball Aerospace and Technologies Corp. to build a mock-up of a re-MAKING AMERICA SAFE | SPACE Launch Initiative to develop a replacement for the shuttle that will be another two-stage reusable launch vehicle but cost much less to maintain and operate. The Defense Department has piggybacked on that



military tool: able to launch on demand, change orbits depending on where it's needed most, and stay for months before returni . While the unmanned vehic could carry a variety of pay making it a fully customizable lite, one of the most contro ons is to use the SMV to deploy Common Aero Vehicle, a reentr

launched by the SOV, a rocket, or even a high-flying airplane. The SMV could remain in orbit for up to a year before landing autonomously on a runway. Boeing has already built a scale version and dropped it from a helicopter to demonstrate its landing capability. Among the payloads the SMV might carry is the Common Aero Vehicle, a reentry craft intended to deliver weapons from space (see "Bombs Away" at left). MISSILE DEFENSE MISSILE DEFENSE IS THE SINGLE LARGEST R&D category in the Defense Department's budget. The Bush administration has requested more than \$7 billion in fiscal 2003 to build a system capable of shooting down ballistic missiles. But before that occurs, the Pentagon will have to design better infrared satellites than the nation's existing Defense Support Program (DSP) birds. Existing DSP satellites can tell whether a missile has been fired at the United States, but intercepting it requires being able to distinguish

between warheads and decoys, track multiple

objects released by a single booster, and hand off trajectory information to an inter-

SPACEPLANE SMV 2012

Bombs Away The Space Maneuver Vehicle (SMV) would be the ultimate sp

craft that could deliver we ranging from small smart bombs to

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er unmanned spaceplane, called the Space Maneuver Vehicle (SMV), that could be

ceptor vehicle-none of which DSP can do. The Pentagon is developing a two-part replacement technology known as the Space-Based Infrared System (SBIRS) High and Low. High satellites, which will operate in geosynchronous and highly elliptical orbits, will supplant the early-warning DSP spacecraft and give a clearer picture of where a missile is headed upon launch. Satellites in low Earth orbit will provide a closer view for precision tracking of individual warheads. SBIRS High was supposed to be launched within the next few years but it is \$2.2 billion over budget and may never be completed. "We redid the costs, redid the schedule," Undersecretary of Defense Edward Aldridge said at a May 2 press conference, "and the message to the prime contractors, Lockheed Martin and Northrop Grumman, is that they're in a spotlight. If we find that six months from now, the program is going south, I have no hesitation to pull the plug." The SBIRS Low program has also been restructured, and the first of its satellites won't be launched until 2006 at the earliest. Meanwhile, the Pentagon is studying two types of weapons that might someday be used to intercept enemy missiles:

kinetic energy weapons, including "kill vehicles" that would destroy missiles by colliding with them; and directed-energy weapons, such as space-based lasers that could also attack targets on the ground. These research activities are raising the hackles of critics who view them as aggressive behavior that will backfire on the United States. "Putting weapons in space is going to open the door for other nations to do the same," warns retired Army Col. Daniel Smith, chief of research at the Center for Defense Information, a military policy research organization in Washington.

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against "Brown," a small neighboring country. "Blue," a superpower, takes up the fight for "Brown" and a battle in space ensues-waged by spaceplanes, missile defenses, anti-satellite lasers, microsatellites, ground-based lasers, and advanced surveillance and communication satellites. As could have been predicted, military officials concluded that the United

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bility. In Pearl Harbor, the Japanese had airplanes that could attack ships. But even if Russia or China wanted to build an anti-satellite weapon, they

MAKING AMERICA SAFE | SPACE **WEAPONIZATION IS BAD** So far, U.S. military spacecraft are used only for gathering and relaying information. There are indications, though, that the Bush administration plans to "weaponize" space. The clearest signal came in January 2001, even before the new president was sworn in, when a commission chaired by now-Defense Secretary Donald Rumsfeld declared that the United States is more dependent on space than any other nation and "must develop the means to deter and defend against hostile acts in and from space." Failure to protect U.S. satellites, the commission warned, could lead to a "Space Pearl Harbor." Opponents derided this conclusion as a provocative strategy that could precipitate a new arms race. We asked Charles Peña, senior defense policy analyst at the Cato Institute, a libertarian research group based in Washington, to explain why he thinks putting weapons in space is a bad idea. Charles Peña I agree with the commission that our satellites in space are vulerable. But at the same time, nobody has any way to exploit that vulnera-

couldn't feasibly do so for 20 to 30 years. We shouldn't waste money on

POPULAR SCIENCE But even if there isn't yet a lot to fear, what's the harm in

CP The last thing we want to do is to provide incentives that don't exist now

P If history is any indicator, it may in fact be inevitable. I just don't think

for other countries to develop weapons that might jeopardize our space assets. We have more to lose than anyone else by taking an offensive posture.

weapons that will be obsolete by then.

launching weapons to protect our satellites?

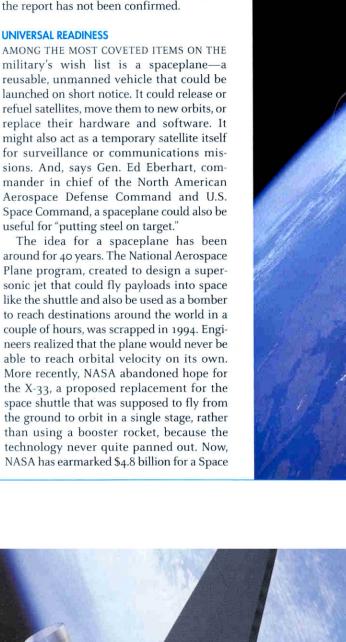
that now is the right time to make that move.

P5 Do you think we should ever weaponize space?

States would have to spend lots more money on space weaponry in the future to fend off the "Reds." "It opened a lot of people's eyes to the importance of space," says Maj. John Wagner, deputy chief of the Space Warfare Center's Wargaming and Simulation Branch at Schriever. In an expanded simulation planned for February 2003,

That's a possibility that the military is preparing for. In Jan-

the players will be battling with even more ambitious equipment from the military's wish list, devices that may not be ready for 15 to 18 years—such as space-based radar, missile interceptors, and reusable launch systems that have yet to be designed. One goal for that weeklong game is to learn more about how all of the armed services can integrate space systems into their battle plans. "Our Cold War forces are evolving into leaner, faster, and more lethal forces," says Wagner. "Space is integral to all of those things." Astronaut Sally Ride worries that space-based military ops will create "space junk." See www.popsci.com/exclusive





weather forecasting, imaging, surveillance, and early warnmanaging and distributing an inintary intormation. With this network, for instance, if an unmanned surveillance plane snaps a picture of al Qaeda operatives on the move, the photo will be immediately relayed to Special Forces units on the ground in time for them to intercept the enemy. tackled by this new communications system is the shortage of bandwidth in many of the communications spacecraft. as early as 2005, the military hopes to begin replacing traditional radio signal technologies on future satellites with advanced laser beam optical systems. The Pentagon has requested \$200 million in next year's budget to jump-start laser communications, which the agency believes would be able to handle even the heaviest communications traffic loads as well as move information

around the globe more quickly by relaying it instantly from satellite to satellite. Work is also under way on new narrowband systems, which are used for voice or low-data-rate communications by soldiers who are able to carry only a limited amount of gear into the field. The multi-satellite Mobile User Objective System, which is scheduled to be launched in 2008, will provide cellphone-type voice and data services via handheld terminals. TODAY'S SATELLITES ARE BIG AND COMPLEX, WHICH MAKES them costly to launch. And once in orbit, there's no inexpensive and simple way to service them. That's why the idea of upgradable satellites is so compelling to the defense industry, whose engineers are borrowing ideas from com-

tle. In a separate program, the Pentagon is designing a smallx machines, but unlike computers or racecars, they can't be upgraded or repaired once they're launched. (The Hubble Space Telescope is a notable exception, but servicing it has required costly space shuttle flights.) The Orbital Express concept overcomes this limitation with small servicing satellites that can inspect larger satellites, refuel them, or replace their software. Servicing satellites (red) could be launched into low orbits, then moved into higher orbits as needed to dock with larger craft. Small, robotic satellites could even attach themselves to enemy satellites as "parasites." SERVICING SATELLITE | ORBITAL EXPRESS | DEMO IN 2006





